

# Chapter 5

## ASSESSING SCIENCE LEARNING



## THE ASSESSMENT PROCESS

Assessment is a way of providing feedback to the various stakeholders in the education system and a way of communicating the expectations of that system to all concerned. The data provide students with feedback on how well they are meeting expectations, teachers with feedback on how well students are learning, districts with feedback on the effectiveness of their programs, and policy makers with feedback on how well policies are working.

Assessment practices also communicate what is important and what is valued in science education. For example, assessments that emphasize the acquisition of factual knowledge imply that facts are important, whereas inquiry-centered assessments indicate that scientific inquiry is important. The methods used to gain educational information should mirror the way teachers teach and should define what students should learn.

National Science Education Standards identified four components of the assessment process: data use, data collection, methods to collect data, and users of data. These components can be combined in numerous ways and should be used to inform decision making and actions taken in science education. National Science Education Standards suggested the following changes in emphases in assessment:

### ***Less Emphasis on . . .***

Assessing what is easily measured

Assessing discrete knowledge

Assessing scientific knowledge

Assessing to learn what students do not know

Assessing only achievement

End-of-term assessments by teachers

Development of external assessments by experts alone

### ***More Emphasis on . . .***

Assessing what is most highly valued

Assessing rich, well-structured knowledge

Assessing scientific understanding and reasoning

Assessing to learn what students do understand

Assessing achievement and opportunity to learn

Ongoing assessment by students of their work and that of others

Involvement of teachers in the development of external measurement

Teachers may use assessment data powerfully and in many ways, such as improving classroom practice, planning curricula, developing self-directed learners, reporting student progress, and researching teaching practices. Science assessments may also be conducted at the district, state, or national levels. These assessments may be used for the purpose of formulating policy, monitoring the effects of policies, enforcing compliance with policies, demonstrating accountability, making comparisons, or monitoring progress toward goals. Assessments may also be conducted by school districts to judge the effectiveness of programs, schools, or teachers and to report district accomplishments.

All levels of the assessment process should include the active participation of teachers of science. Their experiences with students help to ensure congruence of classroom practice with assessment. Therefore, teachers should be an integral part of the development and interpretation of externally designed assessments.

Science educators complain that paper-and-pencil tests are insufficient and give only partial information regarding what students know and what they are able to do. Traditional tests, such as multiple-choice and short-answer tests given at the end of a chapter or unit of study, cannot measure all that goes on in an inquiry-centered science classroom. These tests cannot effectively evaluate whether students have learned how to design an experiment, make accurate observations and measurements, analyze data, and reach reasonable conclusions. Multiple-choice tests are also not very effective in assessing student understanding of concepts such as buoyancy or the role bees play in the life cycle of plants. Measuring students' grasp of these skills and concepts requires alternative forms of assessment, as indicated in the following excerpt from the *Science for All Children* chapter entitled "Assessment Strategies for Inquiry-Centered Science":

Assessing science through paper-and-pencil tests is akin to assessing a basketball player's skills by giving a written test. We may find out what someone knows about basketball, but we won't know how well that person plays the game. (Hein and Price, 1994)

This *New Jersey Science Curriculum Framework* chapter outlines several ways to structure assessment activities that can effectively determine each student's progress toward the attainment of science inquiry skills and concepts. The chapter also describes strategies that can be used to assess the science program as a whole. These guidelines can be used to determine how the implementation of the science program is proceeding.

## ASSESSING STUDENT LEARNING

Just as it is challenging to institute new instructional strategies in the classroom, it is also difficult to incorporate new assessment strategies into classroom evaluation. Creating these strategies is also difficult. Therefore, it is helpful to know that many of the national curriculum programs include such strategies in their teacher's guides. These suggestions provide a good starting point.

The new assessment strategies can be introduced slowly and carefully. It is neither necessary nor advisable to eliminate traditional testing. One of the guiding principles behind assessment is that the more diverse the strategies used, the more that can be learned about each student. A balance of traditional tests and alternative assessments will produce a more complete picture of students' progress.

Although the focus of this *Framework* chapter is on assessment in the classroom, it is important to recognize that assessment is a controversial issue in science education. Within the classroom, using a range of assessment tools provides information on both student learning and future teaching strategies. Within a school district, however, standardized tests are often used as a means of making schools accountable for student learning.

Our focus here is on helping teachers develop more effective strategies for assessing student learning in their classrooms. The following assessment strategies have been used effectively in many science classrooms throughout the country:

- Matched pre- and post-module assessments
- Embedded assessments
- Prediction activities
- Final assessments, such as hands-on assessments, paper-and-pencil tests, and science notebooks
- Informal assessments
- Documentation and record keeping

Many of these assessment strategies, which are discussed below, have been incorporated into national science curriculum programs.

## Matched Pre- and Post-Module Assessments

Pre- and post-module assessments serve two important functions. The first is to track how much students have learned during the unit. For example, the teacher could ask a question or assign an investigation at the beginning of each module to find out how much students know about the subject. At the end of the module, students could answer the same question or perform the same investigation, enabling the teacher to observe how the students' understanding of a subject has grown.

A pre-module assessment can also give the teacher information on what questions students are interested in pursuing. As the class progresses through the unit, the teacher can refer to the pre-module assessment to further refine teaching strategies. The post-module data can then be used as a way for the teacher to measure the success of his or her teaching strategies.

One example of pre- and post-module assessments include brainstorming sessions during which children are asked what they know about a subject and what they would like to learn about it. Other examples include having students write about a subject, draw a picture, or perform a simple experiment. These devices give teachers important "before-and-after" information.

## Embedded Assessments

*Embedded assessments* are woven (embedded) into the instructional sequence in the module. They may be part of the activities that naturally occur in a lesson or a logical extension of the lesson's central activity. Embedded assessments are based on the assumption that assessment and learning are two sides of the same coin. In fact, many educators assert that from the students' vantage point, there should be a seamless flow between instruction and assessment. The biggest difference between embedded assessment and other learning activities is that the assessment is designed to enable the teacher to obtain and record information about student learning.

## Prediction Activities

A *prediction* is different from a guess because a prediction is based on previous experience and knowledge of a subject. By asking students to make predictions at appropriate times, teachers can assess the science concepts their students have mastered and how well they can apply that knowledge to a new situation. For example, during a module on buoyancy, students may be given an assortment of objects and then asked to predict which ones will float and which ones will sink. If students consider the weight and volume in making their predictions, the teacher will know that students have gained some understanding of the buoyancy concept. If they guess randomly, they are telling the teacher that they have a limited understanding of the concept. In either case, the teacher has gained valuable information.

## Final Assessments

These assessments are used at the end of a science unit or module. Although many final assessments include paper-and-pencil tests, they can take many other forms. Examples of final assessments are described below.

**Hands-on assessments.** This type of final assessment provides an opportunity for teachers to observe how well students can perform an experiment similar to one they worked on during the module. Through hands-on assessments, teachers see how students approach a problem, gather data, record results, and draw conclusions from their findings.

Another way to organize hands-on assessments is for the teacher to set up stations throughout the room that offer a series of tasks for students to complete. For example, after performing a module on chemical tests, students may be asked to perform a filtration task at one table, a mixing task at another, and data analysis at a third table. By observing how the students go about the tasks, reviewing the kinds of records they make, and checking the results, the teacher will gain information about what the students have learned. This work can be done individually or in cooperative groups.

**Paper-and-pencil tests.** These are questions included at the end of the unit. The questions can be pictorial or reflective. Pictorial assessments evaluate how well students can think through problems that require both the knowledge and the application of ideas to a new situation. Reflective assessments evaluate how well students can express themselves in writing, as indicated by the way students respond to problem solving questions.

Students could be asked to graph hypothetical data, analyze data from a graph, or discuss a concept in detail. Activities such as these encourage students to go beyond simply recalling isolated pieces of information and to think critically in applying knowledge to new situations.

**Science notebooks.** Students can be asked to prepare individual science notebooks that include all the observations and records generated during a module. The notebooks may include stories and poems, record sheets, charts, tables, and graphs. Drawings also reveal what students have learned. The teacher should assess the level of detail, use of labels, and quality of explanations accompanying the drawings.

Science notebooks are useful for both teachers and students. Notebooks are a powerful assessment tool for teachers and an effective way for students to keep a record of what they have done in the module.

A portfolio is a selected group of student work. Students themselves can select pieces that they feel represent significant learning. Usually, the teacher and students work together to develop selection criteria, which may include materials that were the hardest to do or projects that provoked the most learning. Through this process, students have an opportunity to reflect on what they've learned.

## INFORMAL ASSESSMENTS

Many teachers also find it helpful to conduct informal assessments of students' progress. Such informal assessments involve reviewing written materials, observing students at work, and simply walking around the room and listening to students' conversations. By asking the right questions, teachers can uncover students' reasoning and the steps they used to solve problems. The questions that students ask can also be a source of information about their understanding. In addition, individual and group presentations can give teachers insights into students' interpretation of what they have learned. Finally, questions posed by students following presentations can provide opportunities to gather important information.

## DOCUMENTATION AND RECORD KEEPING

One of the hardest parts of incorporating alternative assessment into the science program is developing an accurate record keeping system. Many teacher's guides include record keeping charts that help teachers focus on the goals of each assessment instrument.

The record keeping devices may include observation sheets, student worksheets, student profile charts, and evaluation rubrics. These devices provide a structure for teachers to use as they experiment with new assessment strategies, and they can be adapted to suit the needs and record keeping styles of different teachers.

## ASSESSING THE SCIENCE PROGRAM

In addition to assessing individual student progress with the new curriculum, school districts need two different kinds of information to assess the overall success of the science program. The first (and most challenging to acquire) is information about whether the science program is resulting in significant changes in teaching and in student learning. National Science Education Standards addressed this issue and acknowledged the difficulty in gathering this information, which needs to include the assessment of student knowledge and skills over time as well as changes in students' attitudes toward science.

The second kind of information that school districts need is a measure of how they are progressing in their efforts to address each of the five elements of science education reform:

- Curriculum
- Professional development
- Materials support
- Assessment
- Administrative and community support.

As stated in the *National Science Education Standards*, "Assessment policies and practices should be aligned with the goals, student expectations, and curriculum frameworks" (NRC, 1996). Alignment of assessment with teaching and learning is critical. The assessment system at the school and district levels should reflect the standards and measure what is valued. New assessment policies and practices at the classroom and district levels that are consistent with the program goals should be developed.

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## NEW JERSEY STATEWIDE SCIENCE ASSESSMENT

In concert with the adoption of *Core Curriculum Content Standards*, New Jersey has implemented a statewide testing program intended to measure student progress toward the achievement of the standards in grades four, eight and eleven/twelve. The first subject selected as an addition to the traditionally tested areas of mathematics and language arts was science, and as of this writing, a science component has been added to the fourth grade Elementary School Proficiency Assessment (ESPA) and will soon be part of the Grade Eight Proficiency Assessment (GEPA) and the High School Proficiency Assessment (HSPA). The HSPA will serve as a requirement for graduation from New Jersey's high schools.



At the urging of the science community, the importance of science as a **process** as well as an area of content knowledge was recognized by the designers of the statewide program when it was agreed that each test would include a “hands-on” performance task assessing the investigative skills that are at the heart of the science standards. A series of such tasks were designed and field tested as part of fourth grade assessment in the spring of 1998 and will appear as part of the GEPA and HSPA in the coming years.

Documents available from the state Department of Education have already been distributed to schools, providing information regarding the alignment of the standards with planned statewide assessments. However, as mentioned in the introduction to this Science Framework, a companion document will be produced, specific to science, that will include samples of assessment activities, and more importantly, useful information for teachers regarding the best ways to design performance assessments as an integral part of science instruction. Additionally, this supplemental publication will discuss classroom strategies to prepare New Jersey’s students for all types of standards based testing.

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